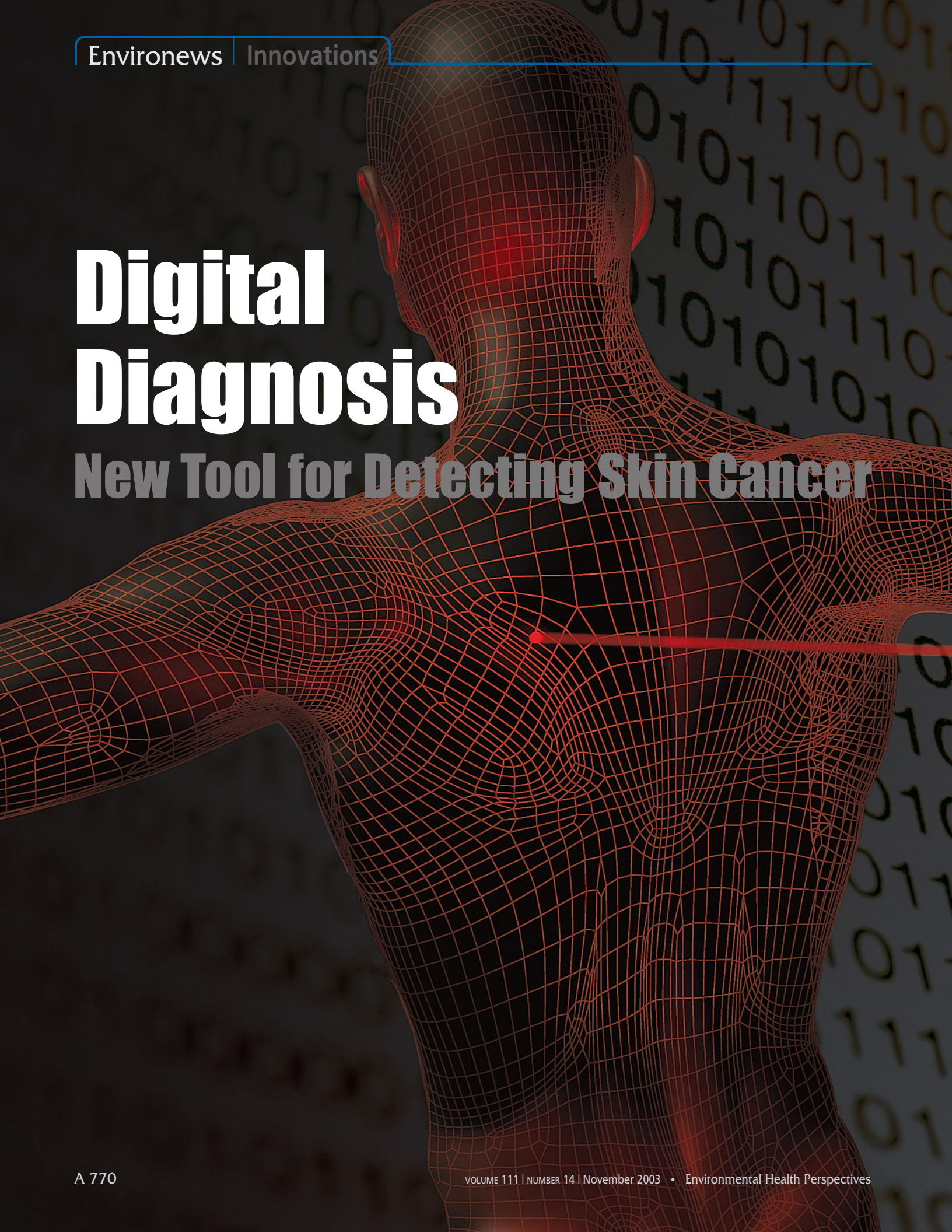
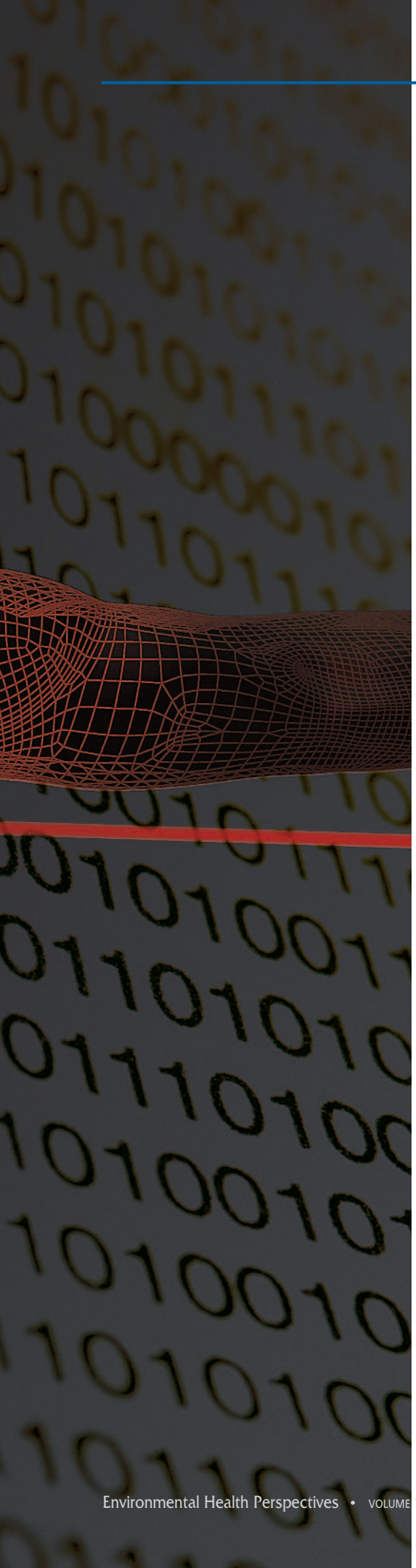


Digital Diagnosis

New Tool for Detecting Skin Cancer



Chris Reuther/EHP

There are tradeoffs to enjoying one's day in the sun. The obvious pleasures of outdoor recreation come at the cost of accelerated aging of the skin, formation of cataracts and other damage to the eyes, and increased risk of skin cancers. The deadliest of the skin cancers, melanoma, has been specifically tied to recreational exposure, as during summertime sunbathing and gardening. Although fatal when allowed to spread, melanoma is easily treated when diagnosed early. But traditional screening is time-consuming and labor-intensive, requiring examination of the entire skin for what may be tiny irregularities. Thus, it is underused.

However, recent advances may signal the dawn of a new era in skin cancer detection. The combination of computer science, applied mathematics, and high-quality, relatively low-cost optics has allowed the development of new tools that let computers do the grunt work of skin screening, highlighting potentially cancerous areas of skin for closer examination by clinicians.

Early Detection Saves Lives

Melanomas are cancers of the cells that produce melanin, the pigment that colors our hair, skin, and eyes. Diagnosis follows an "ABCD" rubric: the cancer's loss of normal growth control can lead moles and other skin spots to become ***A***symmetric, display irregular or blurred ***B***orders, develop an uneven or unusual ***C***olor, or change in ***D***iameter. In melanoma, the depth of a lesion's penetration is an indicator of its severity. When caught at an early stage, when it is still less than a millimeter thick and confined to the outer layer of skin, melanoma is among the most curable cancers. But melanomas that are diagnosed at a later stage, when the melanocytes have grown through the skin and its underlying fat and traveled to sites beyond, are deadly. While the majority of skin cancers are less frequently fatal but still serious basal cell and squamous cell carcinomas, melanoma causes 79% of skin cancer deaths, according to the American Cancer Society.

"The fundamental issue of melanoma is to pick it up before it spreads," says Scott Menzies, director of the Sydney Melanoma Diagnostic Centre at Royal Prince Alfred Hospital in Sydney, Australia. The center is part of the Sydney Melanoma Unit, the

largest melanoma treatment center in the world, where more than 10,000 people with melanoma are treated each year.

The United Nations Environment Programme (UNEP) estimates that more than 130,000 malignant melanomas develop each year worldwide. Although melanoma strikes people of all races, its incidence is concentrated in pale-skinned people, whose relative lack of pigmentation gives them comparatively less natural protection from damage by ultraviolet radiation than those with darker skin. The problem is especially dramatic in places where light-skinned people spend time close to the equator.

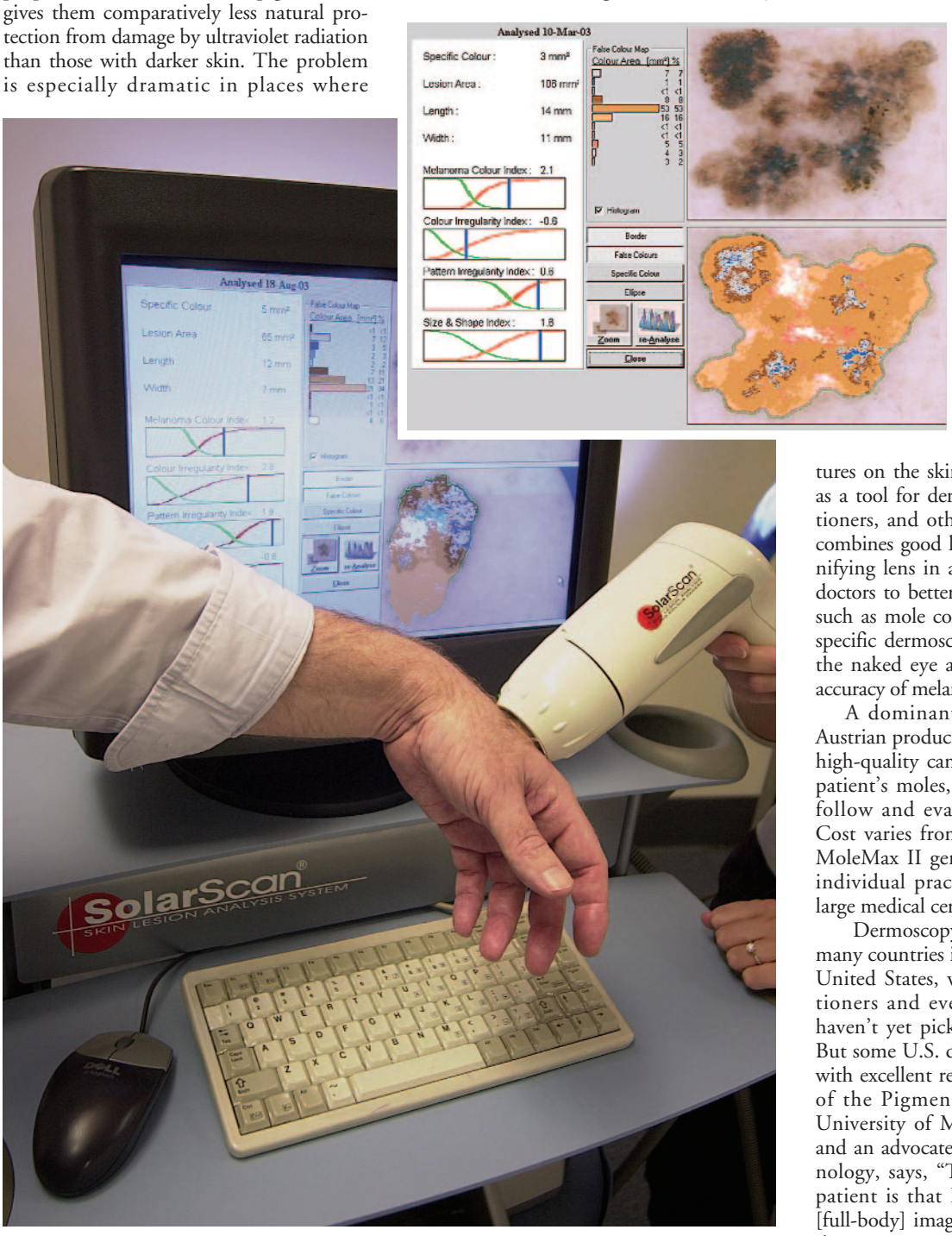
Australia, a nearly equatorial country with a large population from British and northern European stock, is ground zero for skin cancer. One in every two Australians will get skin cancer at some time. More than 720,000 suspected skin cancers are removed in Australia each year, at a cost to the federal government's widely used public health services of more than US$200 million. Of these, about 1 in 30 turns out to be melanoma. In the United States, according to the American Cancer Society, more than 54,000 new cases of melanoma are diagnosed each year.

Physician diagnosis of early melanoma focuses on physical examination of the skin surface. But the skin has a daunting array of freckles, bumps, and irregularities. Natural variations in skin color and texture complicate matters further, as does hair. All these factors make it difficult to spot subtle changes that occur over time. Despite the well-known need for screening, studies have shown that more melanomas are first identified by patients themselves than by physicians.

During the 1990s, dermoscopy—also called epiluminescence microscopy because it lights and magnifies features on the skin's surface—was developed as a tool for dermatologists, general practitioners, and other clinicians. Dermoscopy combines good lighting and a modest magnifying lens in a handheld device to allow doctors to better view and evaluate features such as mole color and shape. Looking for specific dermoscopy features not seen with the naked eye allows increased diagnostic accuracy of melanoma and benign moles.

A dominant tool in this field is the Austrian product MoleMax II, which uses a high-quality camera to record images of a patient's moles, allowing the physician to follow and evaluate changes over time. Cost varies from country to country, but MoleMax II generally is priced for use in individual practitioners' clinics, not just large medical centers.

Dermoscopy is the standard of care in many countries in the world, but not in the United States, where most general practitioners and even dermatologists simply haven't yet picked up on the technology. But some U.S. doctors do use dermoscopy, with excellent results. Robert Johr, director of the Pigmented Lesion Clinic at the University of Miami School of Medicine and an advocate of greater use of the technology, says, "The benefit for the at-risk patient is that I can create a database of [full-body] images and dermoscopy images that I can map out and follow over time." This allows him to identify potential problems early.



SolarScan. This dermoscopy technology uses image analysis including steps such as computerized border selection (top) and lesion color detection, coupled with established diagnostic criteria, to identify potential melanomas for closer inspection.

Polartechnics

Simple Rules

Advances in computer science and applied mathematics are now allowing the basic technology of dermoscopy to be extended to a more complex application: predicting whether observed spots are cancerous. Several teams are working toward computer-assisted diagnosis of melanoma using different mathematical and analytical strategies.

First to reach the market is SolarScan, a device priced for use by individual practitioners and developed by Australian startup Polartechnics, with assistance from Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Sydney Melanoma Unit. SolarScan's strength is in its image analysis, which has turned diagnostic criteria used by doctors into defined "decision trees" that lead toward or away from a decision to call a region of skin a potential melanoma. The company is developing similar approaches for diagnosing other optically accessible cancers, such as cancer of the cervix.

"The way we diagnose [skin cancers] clinically is to look at morphological patterns—we look for patterns that are different in malignancy," Menzies says. SolarScan's proprietary software translates that process into rules that a computer can follow when characterizing images.

To develop these rules, a team of analysts headed by Leanne Bischof, who leads the CSIRO Image Analysis Group, extracted from clinicians exactly what they look for in diagnosing melanoma. "You have to get the skin specialists to describe what's happening unconsciously when they look at a lesion—get them to explain explicitly what the visual pattern is they're looking for," she says.

Victor Skladnev, a lead engineer on the project and managing director of Polartechnics, agrees. "In extrapolating to medicine, the question was what features in the melanoma could be . . . translated into simple rules." In the end, SolarScan's computer brain was trained to weigh the many visual factors that tell a human when to look closer at a spot, enabling it to make decisions about when to label the spot a potential melanoma rather than a harmless freckle.

MelaFind, a melanoma diagnosis system currently in phase III clinical trials in the United States, approaches the problem of diagnosis with a different strategy. This system, being developed by the small New York company Electro-Optical Sciences with advice from clinicians at Harvard, the University of Louisville, and New York University, uses spectra at 10 wavelengths to gather multiple views of a skin lesion's structure.

MelaFind. This technology uses light to penetrate the skin. The device takes multiple views of suspicious spots, providing information on cellular array disorder, an indicator of melanoma.

"The longer the wavelength, the deeper the penetration of light into the skin," explains Marek Elbaum, president and CEO of Electro-Optical Sciences. Using this approach, MelaFind measures a suspicious spot's depth of penetration and estimates the stage of any potential melanomas that it identifies.

MelaFind does not look at the typical clinical rules for diagnosing melanoma, the way SolarScan does. Rather, it examines a skin spot for disorder in how its cells are assembled—a consistent sign of the out-of-control growth that characterizes cancer. The machine moves beyond human comprehension of order and disorder, using statistics to quantitate whether and how a region of cells is in disarray.

"We are motivated by physicians' observations," Elbaum says, "but the measures that we are using are completely different. When a physician is looking at the image, his brain is not using statistics measures. He is using his brain and his gestalt to look at [the spot's] features. We are looking at statistical representations of cellular architecture."

Like physicians, both of these systems will build up experience over time. But the experience will be stored in shareable databases, not an individual practitioner's memory.

Continuing Education

Neither SolarScan nor MelaFind are working toward replacing physicians. "We have taken the approach of not pushing out a [definitive] answer, but rather parameters that indicate to the doctor, 'You'd better have a closer look,'" Skladnev says. The technologies have their gaps, too—primarily the fact that neither product works well on nonpigmented "pink lesions," which represent about 5% of melanomas.

But will such systems ever diagnose cancer as well as or better than a trained clinician? "There's not enough data to tell how good they're going to be," says Harold Rabinovitz, a physician who has done trials with both SolarScan and MelaFind in his Florida private practice. The ability of these systems to diagnose skin cancers with high sensitivity will come to pass, he says. But the devices must be "fed" data from many more cancerous lesions before they will surpass human expertise.

Menzies has a similar view. "You're going to need human intervention, but you'd have to be very pessimistic to believe that, in a generation, they're not going to be better than a clinician," he predicts. "The database will just be more experienced than any clinician."

Victoria McGovern

Suggested Reading

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Electro-Optical Sciences